RTCA Special Committee 209

ATCRBS / Mode S Transponder

Meeting #5

RTCA, Washington DC
5 – 7 December 2006

ARINC Track Angle Rate Issue
Action Item WG49A8/02

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SUMMARY

As per Action Item WG49A8/02, this Working Paper provides detailed discussion of issues that are known with definition of Track Angle Rate in various ARINC documents. It asks ARINC to review and provide commentary as necessary and also to advise WG-49 and SC-209 as to how the situation can be resolved.

TO: Paul J. Prisaznuk
ARINC Standards Development
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November 7, 2006

FROM: Robert H. "Bob" Saffell
Rockwell Collins, INC.,

SUBJECT: Needed Changes to ARINC Specification and Characteristics

Paul,

The following provides detailed discussion of issues that are known with definition of Track Angle Rate in various ARINC documents. Please review and provide commentary as you deem necessary and also advise as to how the situation can be resolved.

Introduction / Abstract:

Enhanced Surveillance capability requires that BDS Register 5,0 of the Mode-S Transponder have bits 35 –through- 45 filled with Track Angle Rate data. The data is required to have a range of +/- 16 degrees / second with a resolution of 0.03125 degrees / second. Most aircraft installations expect to obtain Track Angle Rate data via an ARINC Label "335" word. Recent inspection and analysis of the various ARINC Characteristics and Specifications that address the "335" word has revealed that there is inconsistency in the definition of the "335" word in regards to Track Angle Rate information. This paper details the problem and recommends appropriate updates or clarifications to the various ARINC documents that are impacted.

Discussion:

Table 1 provides definition of how Track Angle Rate data should be mapped into BDS Register 5,0 of the Mode-S Transponder in order to meet Enhanced Surveillance requirements currently in place in Europe. Note that the data is expected to have a range of +/- 16 degrees / second and a reported resolution of 0.03125 degrees / second.

Table 1: BDS 5,0 Track and Turn Report, Track Angle Rate Subfield

BDS 5,0 TRACK AND TURN REPORT, TRACK ANGLE RATE SUBFIELD		
Field Bit	**Field Name**	**Notes**
35	**STATUS**	
36	**SIGN**	Range = +/- 16 degrees / second Resolution = 0.03125 degrees / second
37	**MSB = 8 degrees / second**	
38	**TRACK ANGLE RATE (ARINC Label 335)**	
39		
40		
41		
42		
43		
44		
45	**LSB = 0.03125 degrees / second**	

Table 2, is replicated directly out of ARINC Specification 429 Part 1-16 and provides baseline definition of label "335" Track Angle Rate data as it is supposed to be provided by the various sources identified by the "Equipment ID" in the table. The "Notes" column has been added to Table 2 in order to show the system acronym for each of the sources identified by the "Equipment ID".

Table 2: ARINC Specification 429 Part 1-16 definition of Track Angle Rate in Label "335"

ARINC Specification 429 (September 27, 2001), Part 1-16, Table 2, Page 71											
Label	**Eqpt ID (HEX)**	**Parameter Name**	**Units**	**Range (Scale)**	**Sig Bits**	**Pos Sense**	**Resolution**	**Min Transmit Interval (msec) 2**	**Max Transmit Interval (msec) 2**	**Max Trans-Port Delay (msec) 3**	**Notes**
335	002	Track Angle Rate	Deg/Sec	**32**	**11**		**0.015**	10	20		FMS
	004	Track Angle Rate	Deg/Sec	**32**	**11**		**0.015**	10	20		IRS
	005	Track Angle Rate	Deg/Sec	**32**	**11**		**0.015**	10	20		AHRS
	038	Track Angle Rate	Deg/Sec	**32**	**11**		**0.015**	10	20		ADIRS
	056	Track Angle Rate	Deg/Sec	**32**	**11**		**0.015**	10	20		GLNU
	060	Track Angle Rate	Deg/Sec	**32**	**11**		**0.015**	10	20		GNU

Review of Table 2 shows that Track Angle Rate is defined as having 11 significant bits, range of 32 degrees / second and a resolution of 0.015 degrees / seconds. For ARINC 429 Binary Data (BNR), this definition translates into a Most Significant Bit (MSB) of 16 degrees / second, a Least Significant Bit (LSB) of 0.015625 degrees / second, and an always positive sense. Specifically, the definition does not provide for a negative sense which could allow the range to be expanded to +/- 32 degrees / second with a resolution of 0.015625 degrees / second.

Next, Table 3 is replicated directly out of ARINC Characteristic 718A and provides baseline definition of label "335" Track Angle Rate data as it is expected by the Mode-S Transponder. Once again, Table 3 indicates that label "335" should be defined as discussed for Table 2 in the previous paragraph. As the author of this document was significant party to the development of ARINC 718A, it is known that the definition of Label "335" in ARINC 718A was taken directly from ARINC 429. Therefore a possible error in ARINC 429 would have been ported to ARINC 718A.

Table 3: ARINC Characteristic 718A definition of Track Angle Rate in Label "335"

ARINC Characteristic 718A (February 15, 2002), Attachment 3A, Page 81							
Label	**Parameter Name**	**Units**	**Pos Sense**	**Range (Scale)**	**Sig Bits**	**Resolution**	**Max Transmit Interval (msec)**
335	Track Angle Rate	deg./Sec	**+**	**32**	**11**	**0.015**	20

Next, Table 4 is replicated directly out of ARINC Characteristic 704A and provides baseline definition of label "335" Track Angle Rate data as it is expected to be provided as a binary output from the Inertial Reference System (IRS). Note that the IRS is a platform that can actually measure track angle rate; therefore, it should be considered as the baseline for defining Track Angle Rate as a parameter. Note that Table 4 shows that Positive Sense is clockwise, Binary Range is +/- 32 degrees / second, Resolution is approximately 0.015 degrees / second, and that there are 11 significant bits. The Sensor Range shown at +/- 132 degrees / second is considered to be in error and should be corrected to +/- 32 degrees / second in ARINC 704A.

Table 4: ARINC Characteristic 704A definition of Track Angle Rate in Label "335"

ARINC Characteristic 704A (March 26, 1999), Attachment 13, Page 39____Inertial Reference System (IRS)														
Octal Label	**Parameter**	**Signal Format**	**Max Filter Bndwdth (Hz) [1]**	**Max Transmit Delay (us) [1]**	**Min Update Rate (Hz) [1]**	**Signif. Bits (BNR)**	**Binary Range [2]**	**Sensor Range [2]**	**Approx. Resolution**	**Accuracy [3]**	**Units**	**Positive Sense**	**Self Test Value**	**Notes**
335	Track Attitude Rate	BNR	8*	40	50	**11**	**+/- 32**	+/- 132	**0.015**	0.25	Deg/Sec	**CW**	4^{o}/Sec	

Next, Table 5 is replicated directly out of ARINC Characteristic 705-5 and provides baseline definition of label "335" Track Angle Rate data as it is expected to be provided as a binary output from the Attitude and Heading Reference System (AHRS). Note that the AHRS is also a platform that can actually measure track angle rate; therefore, it should also be considered as the baseline for defining Track Angle Rate as a parameter. Note that Table 5 shows that Positive Sense is clockwise, Binary Range is +/- 32 degrees / second, Resolution is approximately 0.015 degrees / second, and that there are 11 significant bits. As such, Table 4 and Table 5, e.g., IRS and AHRS platforms, are in agreement in regards to defining label "335" Track Angle Rate binary output data. Note that the Sensor Range in Table 5 is +/-32 degrees / second, and is appropriate.

Table 5: ARINC Characteristic 705-5 definition of Track Angle Rate in Label "335"

ARINC Characteristic 705-5 (April 30, 1985), Attachment 10, Page 28_____Attitude and Heading Reference System (AHRS)														
Parameter	**Octal Label**	**Signal Format**	**Max Filter Bandwdth (Hz)**	**Max Transport Delay (MSEC)**	**Min Update Rate (SPS)**	**Signif. Bits**	**Binary Range**	**Sensor Range**	**Approx. Resolution**	**Accuracy [2]**	**Units**	**Positive Sense**	**Self Test Value**	**Notes**
Track Angle Rate	**335**	BNR	8*	40	50	**11**	**+/- 32**	+/- 32	**0.015**	0.25	Deg/Sec	**CW**	4^{o}/Sec	

Next, Table 6 is replicated directly out of ARINC Characteristic 738A-1 and provides baseline definition of label "335" Track Angle Rate as it is expected to be provided as a binary output from the Inertial Reference portion of the Air Data and Inertial Reference System (ADIRS). Note that Table 6 shows that Positive Sense is clockwise, Resolution is approximately 0.015 degrees / second, and that there are 11 significant bits. However, Table 6 shows that the Binary Range and Sensor Range are +/- 128 degrees / second. This is obviously in error for the Binary Range as it is impossible to report a range of +/-128 degrees / second to a resolution of approximately 0.015 degrees / second with only 11 significant bits. Therefore, ARINC 738A-1 should be corrected to show the Binary Range as +/- 32 degrees / second. Also, it should be verified that the Sensor Range should probably be changed to +/- 32 degrees / second.

Table 6: ARINC Characteristic 738A-1 definition of Track Angle Rate in Label "335"

ARINC Characteristic 738A-1 (July 31, 2001), Attachment 7-1, Page 67_____Air Data and Inertial Reference System (ADIRS)														
Parameter	**Octal Label**	**Signal Format**	**Max Filter Bandwdth (Hz)**	**Max Transport Delay (MSEC)**	**Transmit Interval (Msec)**		**Signif. Bits**	**Binary Range**	**Sensor Range**	**Approx. Resolution**	**Accuracy**	**Units**	**Positive Sense**	**Self Test Value**
					Max	Min								
Track Angle Rate	**335**	BNR	8*	40	20	10	**11**	**+/- 128**	+/- 128	**0.015**	0.1 or 1%	Deg/Sec	**CW**	4^{o}/Sec

ARINC 702A-1 (January 31, 2000) Advanced Flight Management Computer System, Section 5.2.12 and Table 2-1, Page 33, identifies that label 335, Track Angle Rate, BNR should be provided as an output on the Aircraft State and Intent Output GNU Bus. Other than that, there is no formal definition of label 335 in ARINC 702A-1. Likewise, section 5.2.12.1 of Draft 2 of Supplement 3 to ARINC 702A-1 does not provide formal definition of label 335.

ARINC 756-2 (February 29, 2000) Global Navigation and Landing Unit (GLNU), Attachment 4-2, Page 80, identifies that label 335, Track Angle Rate, BNR should be provided as an output on the FMS Trajectory Bus. Other than that, there is no formal definition of label 335 in ARINC 756-2.

ARINC 760-1 (March 20, 2000) Global Navigation Unit (GNU), Attachment 4-2, Page 53, identifies that label 335, Track Angle Rate, BNR should be provided as an output on the GNU Trajectory Bus. Other than that, there is no formal definition of label 335 in ARINC 760-1.

Note that none of the Navigation Sources discussed in the previous three paragraphs provide a detailed definition of the label "335" Track Angle Rate parameter. Therefore, it is safe to assume that these Navigation Sources may have deferred to ARINC 429 for definition of the Track Angle Rate binary output. If such is the case, these Navigation Sources may be in error in regards to the binary output of label "335" Track Angle Rate.

Resolution / Request:

Pursuant to the previous discussion, it is believed that label "335" Track Angle Rate should be defined as provided in Table 7, below.

Table 7: ARINC Characteristic 738A-1 definition of Track Angle Rate in Label "335"

LABEL – 335 TRACK ANGLE RATE			
Bit #	**Bit Designation**	**Bit #**	**Bit Designation**
1	1 Label MSB	17	PAD
2	1	18	0.015625 degrees/second
3	0	19	0.03125 degrees/second
4	1	20	0.0625 degrees/second
5	0 **335**	21	0.125 degrees/second
6	1	22	0.25 degrees/second
7	0	23	0.5 degrees/second
8	1 Label LSB	24	1 degrees/second
9	SDI	25	2 degrees/second
10	SDI	26	4 degrees/second
11	PAD	27	8 degrees/second
12	PAD	28	16 degrees/second
13	PAD	29	SIGN (0 = CW, 1 = CCW) ***OR*** (0 = Right, 1 = Left) ***OR*** (0 = East, 1 = West)
14	PAD	30	SSM
15	PAD	31	SSM
16	PAD	32	Parity (ODD)

TRACK ANGLE RATE - SDI CODE		TRACK ANGLE RATE - SSM COD	
(Bits 10,9)	**MEANING**	**(Bits 31,30)**	**MEANING**
00	NOT USED	00	FAILURE WARNING
01	SIDE 1 (LEFT)	01	NO COMPUTED DATA
10	SIDE 2 (RIGHT)	10	FUNCTIONAL TEST
11	UNIT #3 or NOT USED	11	NORMAL OPERATION

On behalf of EUROCAE WG-49 and RTCA SC-209, it is requested that the applicable ARINC Specification and Characteristics be updated as follows:

a. ARINC Specification 429 P1-16:

Update Table 2, Page 71, label "335" definition to be consistent and equivalent to that provided in ARINC Characteristic 705-5, Attachment 10, Page 28.

b. ARINC Characteristic 718A, Attachment 3A, Page 81:

Update Attachment 3A, Page 81, label “335” definition to be consistent and equivalent to that provided in ARINC Characteristic 705-5, Attachment 10, Page 28.

c. ARINC Characteristic 704A, Attachment 13, Page 39:

Update Attachment 13, Page 39, label “335” definition to be consistent and equivalent to that provided in ARINC Characteristic 705-5, Attachment 10, Page 28.

d. ARINC Characteristic 738A-1, Attachment 7-1, Page 67:

Update Attachment 7-1, Page 67, label “335” definition to be consistent and equivalent to that provided in ARINC Characteristic 705-5, Attachment 10, Page 28.

e. Ensure that no other conflict exists between ARINC Specifications and/or Characteristics in regards to the definition of label “335” Track Angle Rate binary output or input data.

Likewise, on behalf of EUROCAE WG-49 and RTCA SC-209, it is requested that the applicable ARINC Characteristics be updated or clarified as follows:

f. ARINC 702A-1, Section 5.2.12, Table 2-1, Page 33:

including Section 5.2.12.1 of Supplement 3:

ARINC 756-2, Attachment 4-2, Page 80: ***AND***

ARINC 760-1, Attachment 4-2, Page 53 :

Add an appropriate Note to ensure that the updated ARINC 429 (subparagraph a, above) definition of label “335” Track Angle Rate is used or provide an errata sheet specifically defining label “335” Track Angle Rate consistent with the definition provided in ARINC Characteristic 705-5, Attachment 10, Page 28.

In addition to the requested updates, appropriate consideration should be given to providing direct advisement to vendors of ARINC 702A, 756, and 760 equipment to ensure that binary output of label “335” Track Angle Rate data should be consistent with subparagraph “a” above.

In closing, all efforts by the ARINC Standards Development Staff are appreciated in resolving these issues with Track Angle Rate data. Hopefully, we can move to ensure consistency in the Enhanced Surveillance use and reporting of such data.

Best Regards,

Bob Saffell
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From: "Prisaznuk,Paul J \(PJP\)" <PJP@arinc.com>
To: <rhsaffel@rockwellcollins.com>
cc: <TBevNichols@aol.com>, Gary CTR Furr/ACT/CNTR/FAA@FAA, Thomas Pagano/ACT/FAA@FAA

Date: Saturday, November 11, 2006 02:02AM
Subject: RE: Needed changes to ARINC Specification and Characteristics

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Bob,

Thank you for bringing this issue to our attention at ARINC. Systems Architecture and Interfaces (SAI) Subcommittee will have an opportunity to discuss this on December 5-7 in SFO. Once there is broad industry consensus, the ARINC Standards will be updated. I hope this is sufficient response for now.

Best regards,

Paul Prisaznuk
ARINC Standards Development

-----Original Message-----
From: rhsaffel@rockwellcollins.com [mailto:rhsaffel@rockwellcollins.com]

Sent: Tuesday, November 07, 2006 1:08 PM
To: Prisaznuk, Paul J (PJP)
Cc: TBevNichols@aol.com; gary.ctr.furr@faa.gov; thomas.pagano@faa.gov
Subject: Needed changes to ARINC Specification and Characteristics
Importance: High

Paul,

Please review the attached Word document in regards to issues with the current definitions of label "335" Track Angle Rate. We need your help in establishing consistency in the manner that this parameter is defined such that we do not have further issues with it in Enhanced Surveillance applications.

Should you have any questions, please feel free to contact me via the email addresses provided or the phone numbers provided below.

Best Regards,
Bob Saffell

321-768-7062
321-652-4641
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(See attached file: ARINC track angle rate.doc)